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Economic Evaluation of Fiscal Regime on EOR Implementation in Indonesia: A Case Study of Low Salinity Water Injection on Field X

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Abstract

There are currently two fiscal regimes designated for resource allocation in Indonesia's upstream oil and gas industry, the Production Sharing Contract Cost Recovery (PSC) and Gross Split. The Gross Split in the form of additional percentage split is designed to encourage contractors to implement Enhanced Oil Recovery (EOR) in mature fields. Low Salinity Water Injection (LSWI) is an emerging EOR technique in which the salinity of the injected water is controlled. It has been proven to be relatively cheaper and has simpler implementations than other EOR options in several countries. This study evaluates the LSWI project's economy using PSC and Gross Split and then to be compared to conventional waterflooding (WF) project's economy. There are four cases on Field X that are simulated using a commercial simulator for 5 years. The cases are evaluated under PSC and Gross Split to calculate the project's economy. The economic indicators that will be evaluated are the Net Present Value (NPV) and sensitivity analysis is also conducted to observe the change of NPV. The parameters for sensitivity analysis are Capital Expenditure (CAPEX), Operating Expenditure (OPEX), Oil Production, and Oil Price. It is found that LSWI implementation using Gross Split is more profitable than PSC. The parameters that affects NPV the most in all PSC cases are the oil production and oil price. On the other hand, in Gross Split cases, the oil production is the parameter that affects NPV the most, followed by oil price. The novelty of this study is in the comparison of project's economy between WF and LSWI using two different fiscal regimes to see whether Gross Split is more profitable than PSC on EOR implementation, specifically the LSWI at Field X.

INTRODUCTION

Indonesia's Ministry of Energy and Mining Resources issued Regulation No. 8 of 2017 (*Permen ESDM No 08 Tahun 2017 Tentang Kontrak Bagi Hasil Gross Split*, 2017) on January 13rd, 2017 to introduce new fiscal regime in resource allocation in upstream oil and gas industry, the Gross Split, and the regulation was amended by Regulation No. 52 of 2017 (*Permen ESDM No 52 Tahun 2017 Tentang Perubahan Atas Peraturan Menteri Energi dan Sumber Daya Mineral Nomor 08 Tahun 2017 tentang Kontrak Bagi Hasil Gross Split*, 2017) to further improve the Gross Split scheme. It is a new oil and gas fiscal regime that the government hopes will restore investor's confidence to invest in Indonesia.

Before the Gross Split was introduced, the model used in Indonesia was Production Sharing Contract (PSC). The PSC was first implemented in Indonesia on August 18th, 1966 in respect of the Offshore Northwest Java Block between Pertamina and Independent Indonesian American Petroleum Company (Roach & Dunstan, 2018).

One of the key differences between Gross Split and PSC is the split calculation between the contractors and the government. Gross Split have variable split and progressive split that adjust the base split, one of the

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variables is production stage. So, if a field is in the tertiary production stage, the Enhanced Oil Recovery (EOR) stage, the contractors will get more split percentage compared to field in the secondary production stage. One of the examples of secondary production stage is waterflooding (WF).

In the past, WF is largely designed without focusing on the composition of the injected water. Low Salinity Water Injection (LSWI) is an emerging EOR technique in which the salinity of the injected water is controlled to improve oil recovery. Core floods and other tests have indicated that changes in the injected water composition can improve basic waterflood performance by 5% to 20% (Dang, Nghiem, Nguyen, Chen, et al., 2015), thereby introducing the promising idea that the LSWI is an emerging EOR technique that is relatively cheaper and has simpler implementations compared to other EOR options.

LSWI has been proven as an emerging technique for improving oil recovery not only from laboratory scale (Hidayat et al., 2018; Marhaendrajana et al., 2018), but also shown on Table 1 a summary of field implementations of LSWI. Compared to the conventional WF and EOR methods, the major advantages of LSWI include considerable recovery benefit, lower cost and relatively simpler to implement, easier to be implemented in both onshore and offshore reservoirs, possible utilization of onsite facilities without requiring a large quantity of chemical or gas for EOR projects, and more environmentally friendly. However, LSWI is dependent on geological setting, Table 2 shows a pre-screening criterion in order to identify the most promising candidates for LSWI implementation (Dang, Nghiem, Nguyen, & Chen, 2015).

Oil wet or mixed wet reservoir could be a good candidate for LSWI application. The reason for this important screening factor comes from the main mechanism of LSWI in which LSWI alters the wettability towards more water wet. Thus, a small modification on relative permeability curves in strong water wet reservoirs may not be enough for achieving enough incremental recovery. Figure 1 shows an example of the schematic shifting of relative permeability curves in LSWI and Figure 2 shows a result of incremental oil recovery by LSWI in preferential oil wet and water wet reservoirs.

Summary from several coreflooding experiments (Akhmetgareev & Khisamov, 2015; Rivet et al., 2010; Shehata et al., 2016) shows that WF and LSWI have different relative permeability curve parameters. Thus, the wettability alteration caused by LSWI can be observed in the difference between the parameters of relative permeability curve. Table 3 shows the parameters of the relative permeability curve.

The Gross Split scheme introduced on Regulation No. 8 of 2017 (as amended by Regulation No.52 of 2017) splits gross revenues derived from hydrocarbon production between the Government and Contractors. Contractors must bear all capital and operating costs subject to such costs being tax deductible if commercial reserves are discovered and production generates taxable revenue (Roach & Dunstan, 2018).

The Government believes that the Gross Split scheme should incentivize exploration and exploitation activities due to the spending and operational "freedom" it conveys to Contractors. The scheme should allow Contractors to focus on cost efficiency and reducing the bureaucratic process for expenditures approval. The scheme is also still allowing the Government to be involved in approving key phases of upstream business developments (PriceWaterCooper, 2018).

The Contractors split are the sum of the base split percentages, variable components, and progressive components. Table 4 specifies the base split percentages and Table 5 specifies the split percentages of all the variable and progressive components.

Tax rules for the Gross Split is explained in Regulation No. 53 of 2017. The general fiscal framework appears broadly in line with that for PSC although further regulations will be required before Contractors can draw more definitive conclusions (*Peraturan Pemerintah Nomor 53 Tahun 2017 Tentang Perlakuan Perpajakan Pada Kegiatan Usaha Hulu Minyak dan Gas Bumi dengan Kontrak Bagi Hasil Gross Split*, 2017).

PSCs have evolved through five "generations" with the main variations on the production sharing split. Since 2008, the fifth generation of PSC with cost recovery mechanism has been introduced (PriceWaterCooper, 2018). Table 6 shows the summary of the PSC scheme split calculation. To ensure a constant after-tax share for Contractors, the before-tax share has adjusted over the years as Indonesia's general income tax has been lowered. Table 7 summarized the calculations for before-tax share, after-tax share, and income tax. Figure 3 shows the comparison between Gross Split and PSC mechanism.

In terms of economic evaluation, LSWI project can utilize facilities of conventional WF, the major difference comes from water desalination cost. There are obvious expenditures for LSWI desalination facilities that depend on several important factors such as salinity of water source, targeted salinity of injected water, field location, project scale, energy cost, and oil price.

The desalination cost for LSWI is not widely reported, however there are several methods for desalination technology, one of them is Electrodialysis Reversal (EDR). The EDR operates by mass flux of ions through membranes, and therefore a greater change in salinity increases mass flux, which increases both membrane area, or the capital expenditure (CAPEX), and the operating expenditure (OPEX) (Sparrow et al., 2018). Therefore, desalination cost by using EDR is a function of the amount of water treated and salinity difference between source water and injected water.

This study is aimed to present a new viewpoint on how the LSWI would be economical enough to be implemented in gross split fiscal scheme, using field X data as a benchmark.

METHODOLOGY

Figure 4 shows the flowchart for this study to be completed. First, literature study is conducted to verify the background and the objectives of this study. The basic theory is also collected in this literature study. Next, four cases are made, the cases are the Base Case (business as usual), WF, LSWI 1, and LSWI 2. The cases will be simulated for 5 years using commercial reservoir simulator. The case project's economy then will be evaluated using PSC and Gross Split scheme to observe the effect of different fiscal regime on LSWI implementation on Field X. Sensitivity analysis will also be conducted to observe which parameter affects the NPV most. The last step is conclusions will be made from the economic evaluation results and sensitivity analysis to see whether Gross Split is more EOR friendly than PSC.

Case Study

The field that is used in this study is Field X. The reservoir in Field X is identified as a sandstone reservoir. Figure 5a and Figure 5b show the inverted 4-spot injection pattern at Field X that is evaluated in this study. In the simulator, a static model dimension is defined by 1450 total active blocks. The water saturation and permeability distribution of reservoir model are shown respectively in Figure 6. The average reservoir pressure is 1200 psia and the average temperature is 151.1 ˚F, reservoir depth is 2000 ft.

There are 4 cases that will be simulated. The first case, Base Case, is natural depletion production so the Well-4 as the injection well is shut off. The second case, WF, is waterflooding project with the assumption that the injected water salinity is 25,000 ppm. The third case, LSWI 1, is LSWI project with the injected water salinity is set at 1000 ppm. The last case, LSWI 2, is also LSWI project with the injected water salinity is set at 2000 ppm.

The LSWI modelling is done using LSWI Process Wizard in the commercial simulator. Table 8 shows the parameter for LSWI modelling that is applied in all the LSWI cases. The effect of wettability alteration is modeled by shifting the relative permeability curves. The author uses the result from coreflooding experiment done by Shehata et al. (2016) to alter S_{or} and K_{rw} for LSWI implementation because in the experiment the injected water is NaCl and on LSWI cases on Field X also using NaCl, therefore on Field X the author assume S_{or} ratio is 0.717 and the K_{rw} ratio is 0.963. Figure 7 shows the relative permeability shifts for this study. The commercial simulator incorporates three dominant mechanisms in modeling LSWI namely using the multi-component ion exchange mechanism, aqueous reaction, and mineral dissolution & precipitation (Pouryousefy et al., 2016). Other mechanisms such as wetting & non-wetting phase interpolation parameters (Hakiki et al., 2015), changes in capillary pressure (Hakiki et al., 2017), surface roughening (Marhaendrajana et al., 2018) is not considered in this problem since it is not included in the process wizard.

All the cases will be simulated for 5 years, starting from January 1st, 2017 until January 1st, 2022. During production, the injection will also be started from the beginning of the simulation and will be run for 5 years also. Liquid group production rate of the pattern is limited to 150 bbl/day. The injection rate is fixed at 100 bbl/day. The minimum bottom hole pressure constraint for each production well is set at 400 psia and maximum bottom hole pressure for Well-4 is set at 2000 psi.

Economic evaluation will be based on cash flow calculation of each cases and the cash flow will be calculated using two schemes, the PSC and Gross Split scheme. The economic indicator that will be evaluated is the NPV. The basis of cash flow calculation is investments and revenues. In this study, the investments consist of CAPEX and OPEX, and the revenues are generated from oil production from Field X.

Base Case has no additional investment, so both the CAPEX and OPEX are zero in the cash flow calculation. WF case have additional investments in waterflooding facilities. LSWI 1 and LSWI 2 case also have additional investments in water desalination facilities and waterflooding facilities. As mentioned before, water desalination facilities cost is a function of the amount of water treated and the removed salinity between source water and injected water. Figure 8 and Figure 9 show the desalination cost function to salinity removed. The EDR is assumed to have 90% efficiency, so the water treated rate is 110 bbl/day for the targeted water injected rate of 100 bbl/day. Table 9 summarizes the investments for WF, LSWI 1, and LSWI 2 cases.

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Table 10 summarizes the general assumptions that is used in this economic evaluation. For Gross Split calculation, there are variables that add the split for Contractor, so Table 11 shows the Gross Split parameter assumptions used in this study.

Sensitivity analysis is conducted to determine which of the following parameters: CAPEX, OPEX, oil production, and oil price, that have the most effect on NPV. The sensitivity analysis is conducted by changing the parameter value with the changing factor of 30%, so the value of the parameters is ranging from 70% to 130%.

RESULTS AND DISCUSSION

The results of the simulation that will be used in this study is the oil production rate. Figure 10 shows the oil production rate for each case and Figure 11 shows the cumulative oil production, the authors observe that in all the cases, oil production rate drops rapidly after a year production. It can be concluded that low reservoir pressure and no aquifer support is the cause of this drop. All LSWI cases have higher cumulative production compared to conventional WF, therefore it can be implied that LSWI implementation on Field X is improving the oil recovery.

All the cases are evaluated using PSC and Gross Split scheme to calculate the NPV of each case. The NPV of Base Case, WF, LSWI 1, and LSWI 2 using PSC scheme are 493.6, 399.5, 410.3, and 405.5 thousand USD respectively. The NPV of Base Case, WF, LSWI 1, and LSWI 2 using Gross Split scheme are 539.5, 513.0, 557.1, and 553.1 thousand USD respectively. Table 12 shows the PSC calculation spreadsheet and Table 13 shows the Gross Split calculation spreadsheet for Base Case, the other cases also use the same calculation spreadsheet format and only changing some of the data for each case. Table 14 summarize the NPV for all the cases.

The authors observe from the NPV summary that in PSC scheme all the cases have smaller NPV than Base Case. It means that additional investments in all the cases using PSC scheme are not resulting in higher revenue for the Contractor, therefore causing the NPV to be smaller compared to the Base Case. On the other hand, in Gross Split scheme, LSWI 1 and LSWI 2 have greater NPV than Base Case and WF. It means that in Gross Split scheme, additional investments in LSWI cases resulting in higher NPV gain. LSWI 1 have the highest additional investment but it also has the highest NPV. Table 15 summarizes the percentage of NPV change for all the cases and the LSWI cases using Gross Split scheme are the only cases that have positive NPV percentage changes compared to its Base Case. The authors analyze the result to find the reasons why implementing different fiscal regime resulting in different NPV for the same case. First, the PSC scheme do not have clear incentives for developing Field X that is in the later stage of the field's life, as for the Gross Split scheme, additional split for implementing EOR turns out to be more profitable when the authors compare it with the PSC scheme. Second, the cost recovery mechanism of PSC will not be recovered fast enough because the oil production rate at Field X is already low from the second year. Cost recovery is paid by giving additional production share for the contractor, but if the gross revenue after First Tranche Petroleum (FTP) is lower compared to the contractor's cost to be recovered, then there will be unrecovered cost. From this analysis, the authors conclude that Gross Split scheme is more profitable for the Contractor than PSC scheme on EOR implementation, in this case LSWI implementation on Field X.

Revenue in Indonesia's oil and gas industry is a zero-sum game between Contractor and Government, which means that to increase the revenue for Contractor, Government's revenue must be lowered and vice versa. In all LSWI cases, the author observes that Government's revenue in PSC scheme is higher compared to Gross Split scheme. There are some reasons for the Government to lower their revenue on EOR implementation using Gross Split scheme in Indonesia, one of the reasons is many fields in Indonesia are mature fields, therefore EOR implementation is needed to increase the oil recovery. Additional split for tertiary recovery production stage in Gross Split scheme is designed to attract more Contractor to invest their money in Indonesia, especially on EOR implementation. More investments in EOR means more mature fields that have their oil recovery improved, it also means that Indonesia is getting the technological know-how in EOR implementations.

Sensitivity analysis is conducted on LSWI 1 in both fiscal regimes to determine which parameter that will affect NPV the most. Figure 12 and Figure 13 show the spider diagram on LSWI 1 for PSC and Gross Split, respectively. From the PSC spider diagram, oil price and oil production are the parameters that will affect NPV the most. The explanation for this result is the gross revenue is generated by multiplying oil production and oil price, and when the authors compare the gross revenue with CAPEX and OPEX, the gross revenue is much larger than the CAPEX and OPEX. Therefore, in PSC scheme, small changes in either oil production or oil price will create bigger changes in the NPV. From the Gross Split spider diagram, oil production is the only parameter that most affecting the NPV. The reason why oil price is not having the same effect as in the PSC scheme is oil price is one of the progressive components that will cause split adjustment for the contractor, if the oil price is high then the contractor split will be lowered and vice versa. This mechanism is the reason that makes the changes in oil price in Gross Split scheme resulting in more stable NPV compared to PSC scheme.

CONCLUSIONS

In summary, this study can be concluded that additional investments in all the cases using PSC scheme are not resulting in higher revenue for the Contractor. Meanwhile in LSWI implementation using Gross Split is more profitable than PSC due to additional split in Gross Split resulting in higher production share for Contractor. Production profile of Field X is not suitable for cost recovery mechanism causing unrecovered cost. The parameters that affects NPV the most in all PSC cases are the oil production and oil price. On the other hand, in Gross Split cases, the oil production is the parameter that affects NPV the most, followed by oil price. One of the ways for incentivizing EOR implementation in Indonesia is giving additional economic benefit in the fiscal regime for the Contractor. Gross Split scheme, as the newest fiscal regime in Indonesia's oil and gas upstream industry, have the incentives for Contractor implementing EOR in Indonesia by giving additional 4% split.

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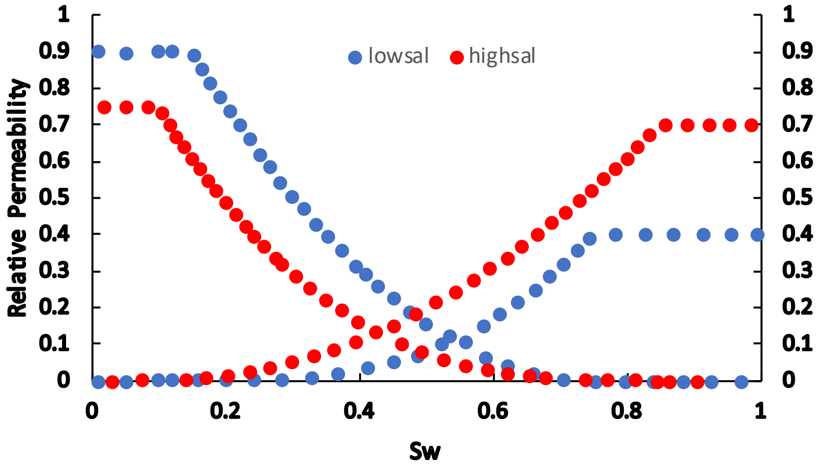
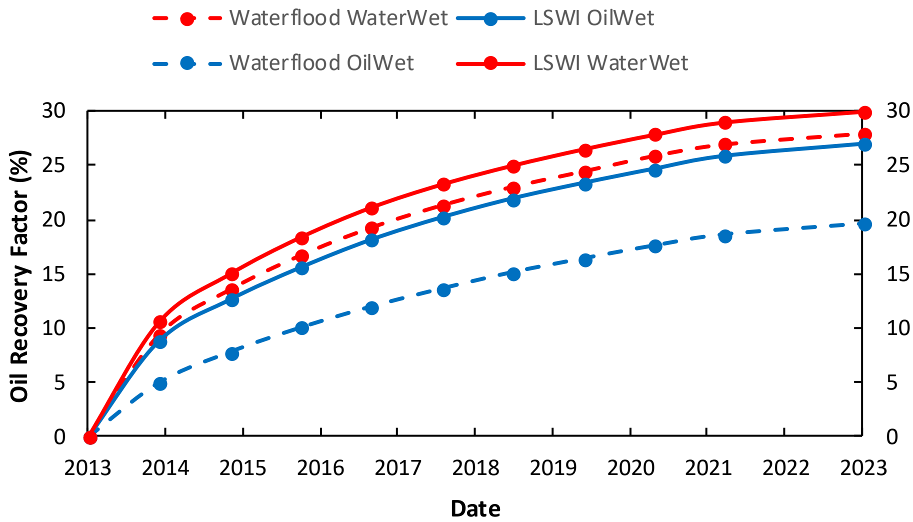


Figure 1. Schematic shifting of relative permeability curves in LSWI (Reproduced from Dang et al., (2013)).



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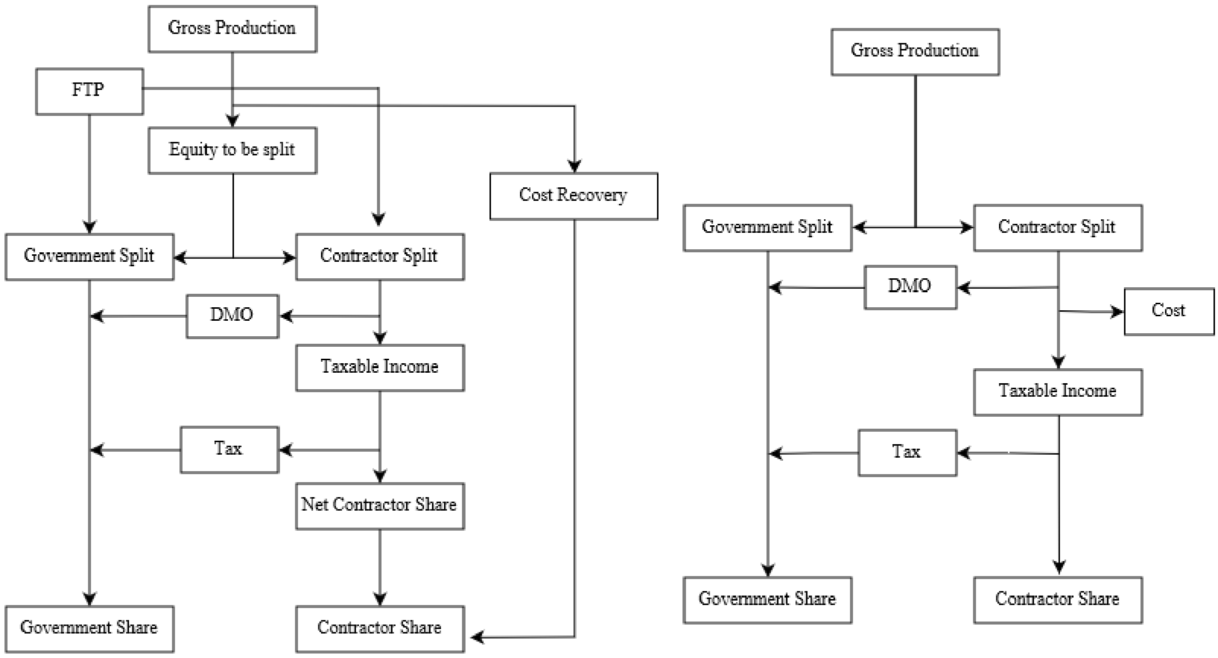

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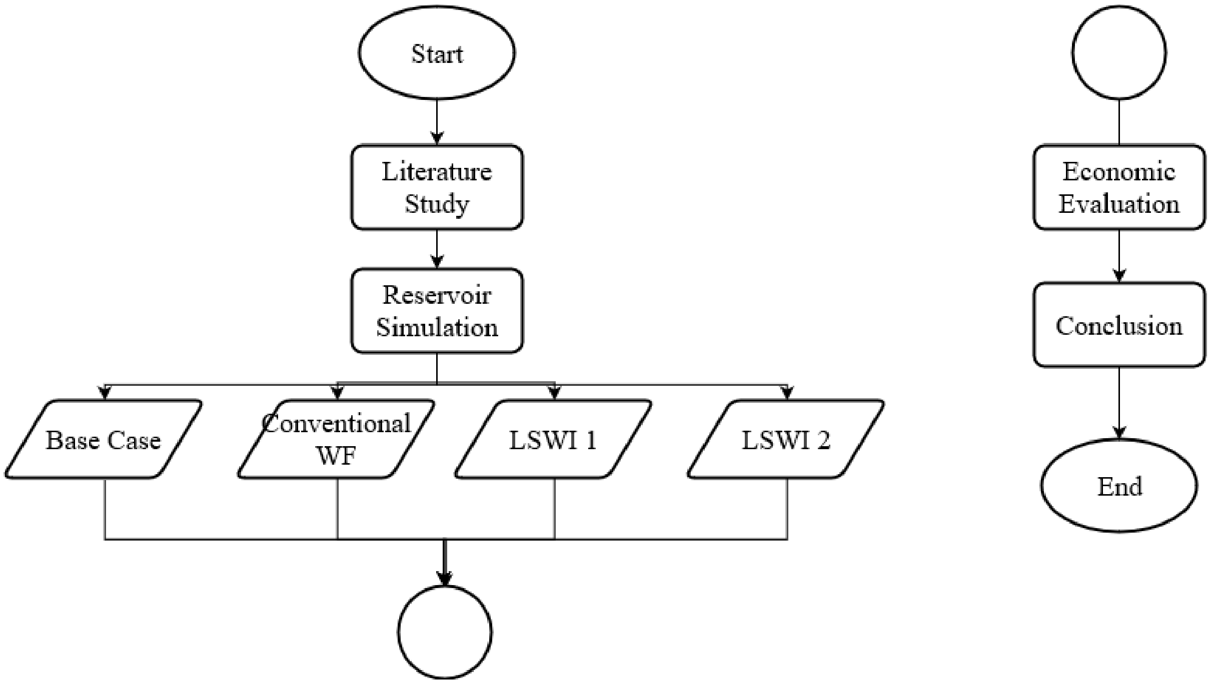

Figure 4. Methodology workflow.

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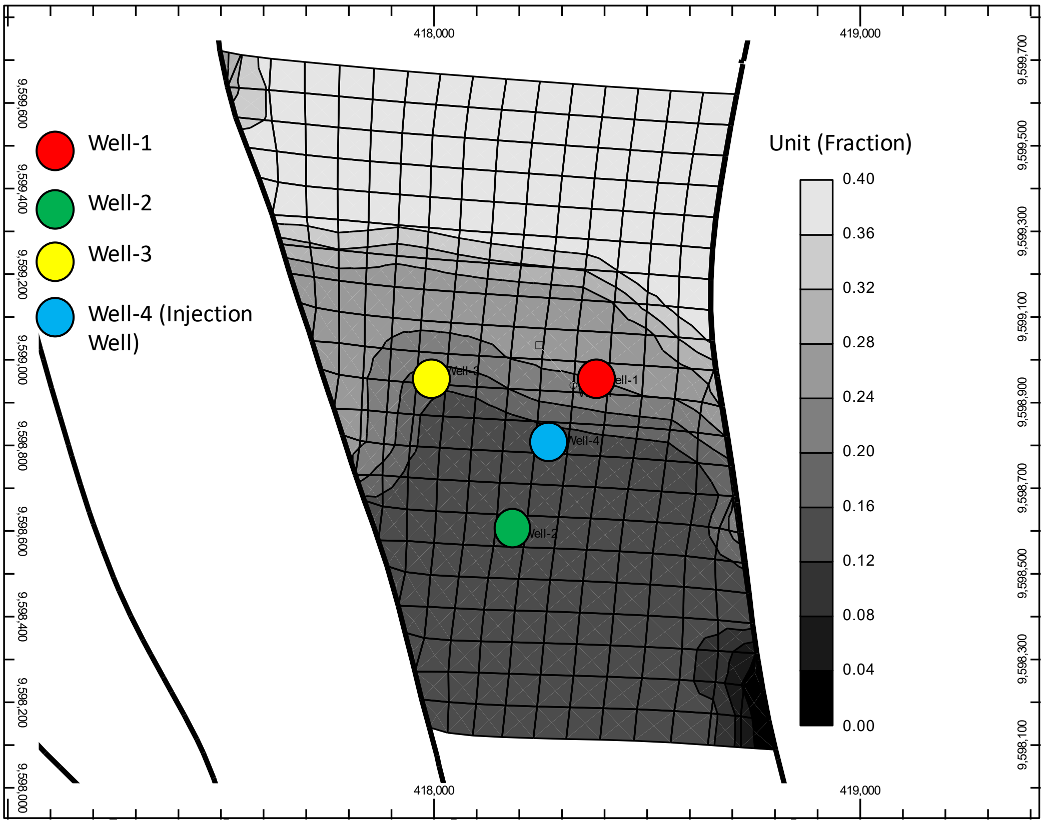

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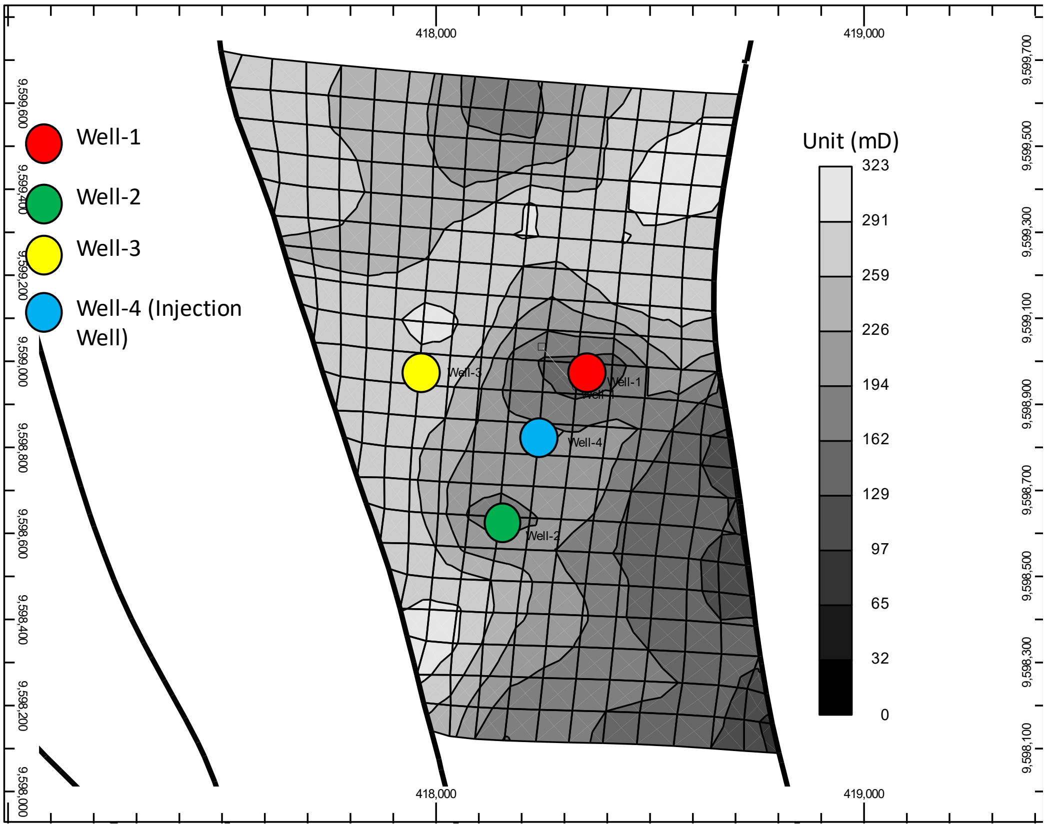

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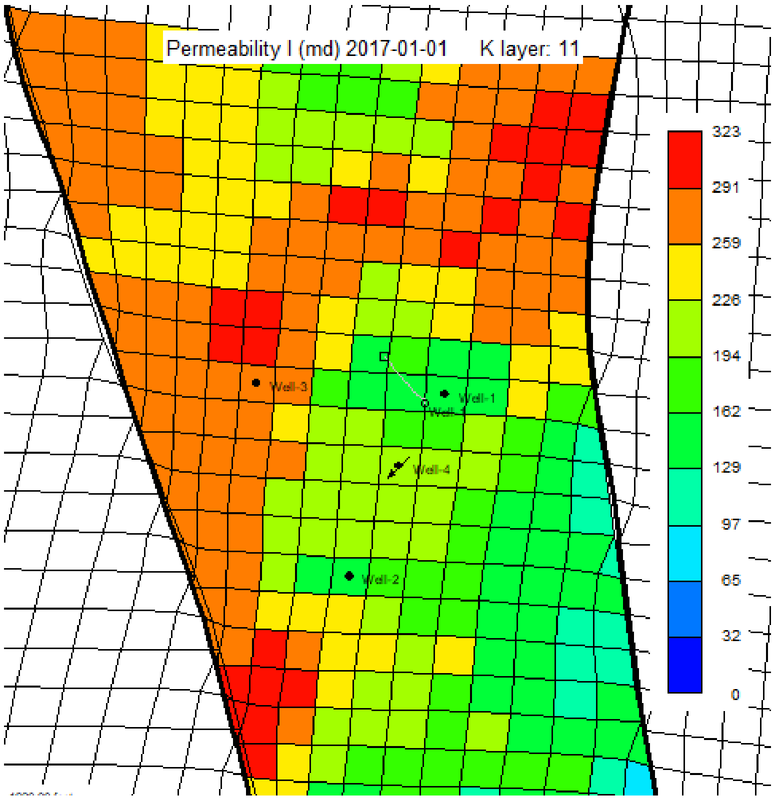

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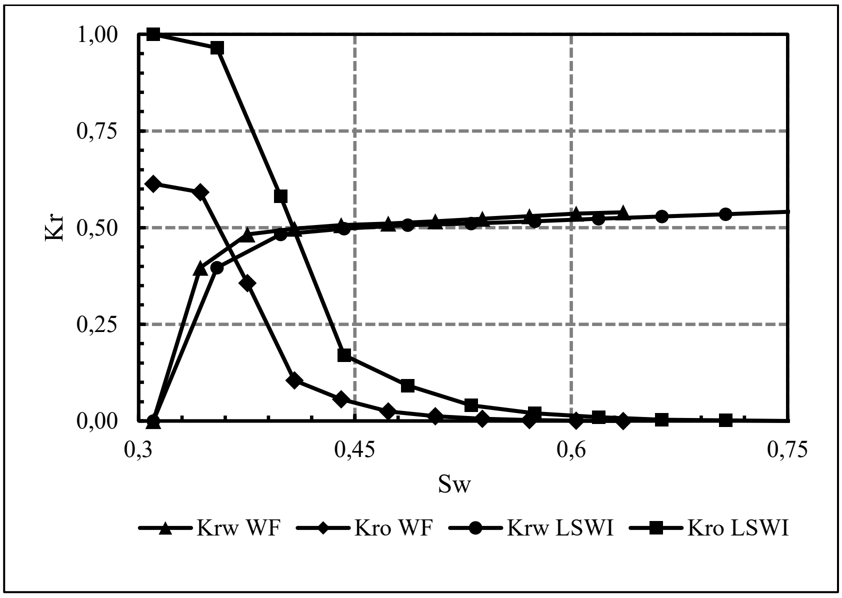

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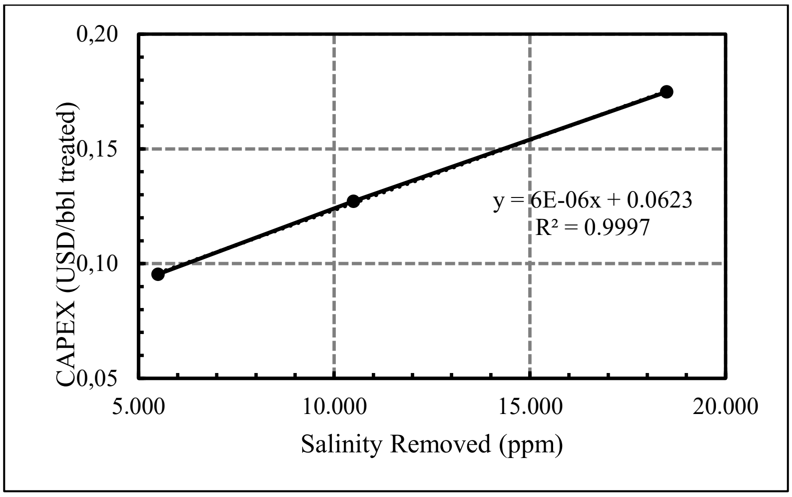

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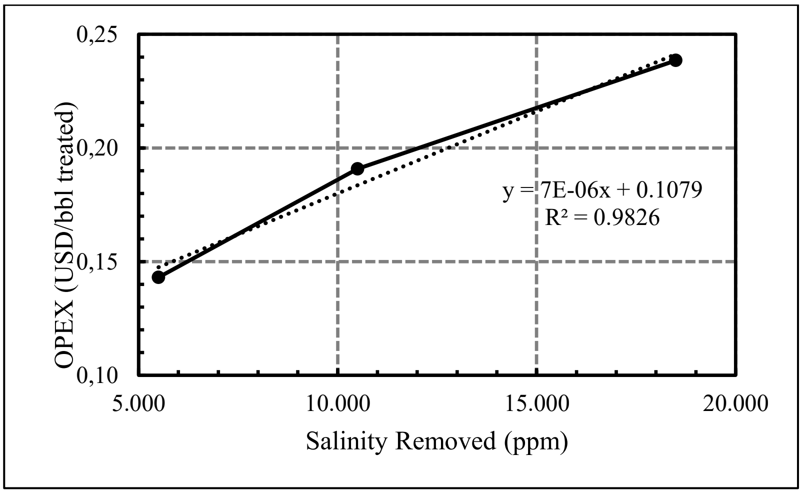

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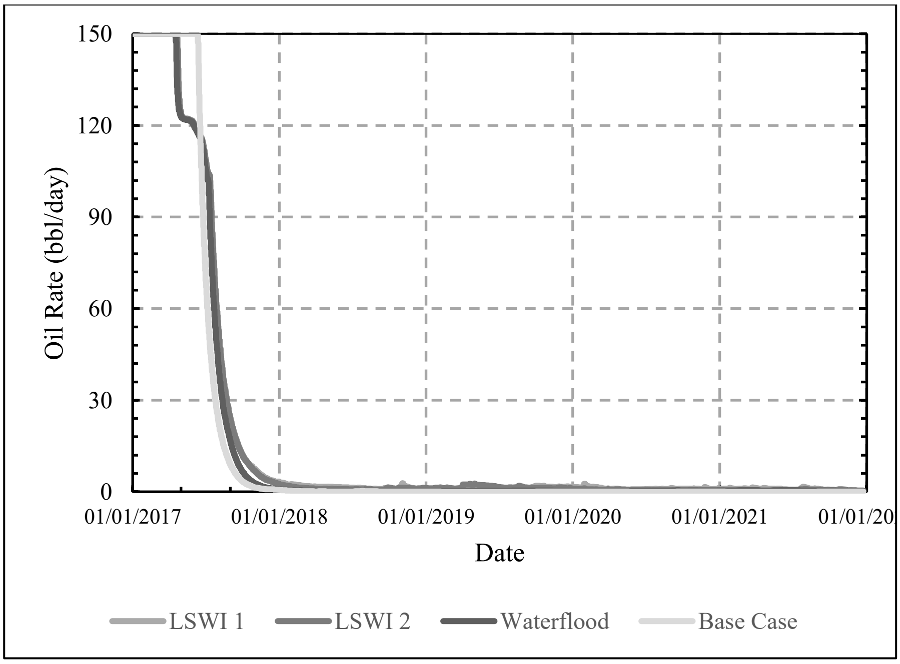

Figure 10. Oil production rate of Field X.

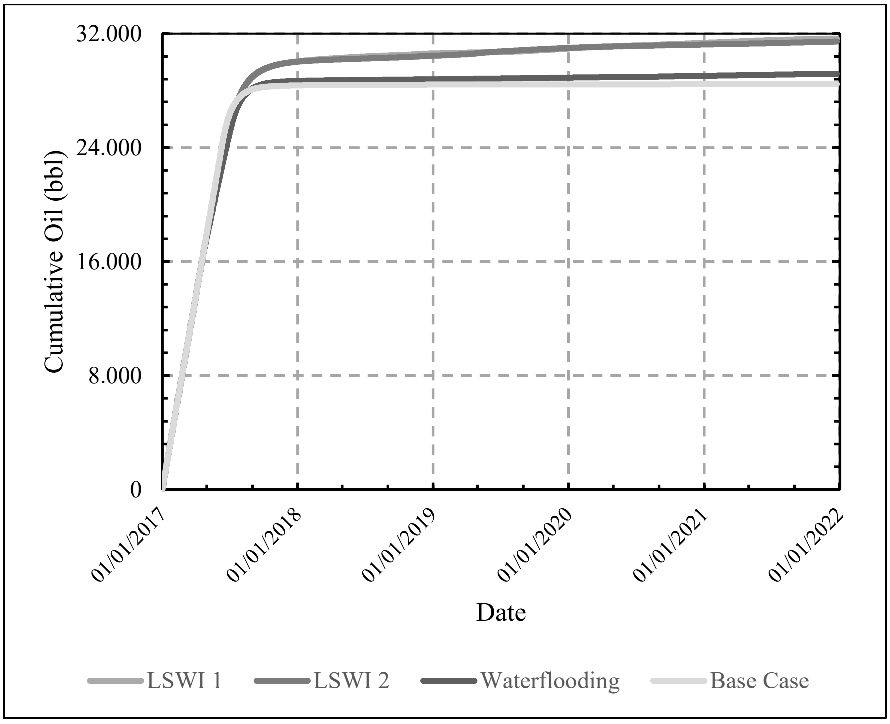

Figure 11. cumulative oil production of Field X.

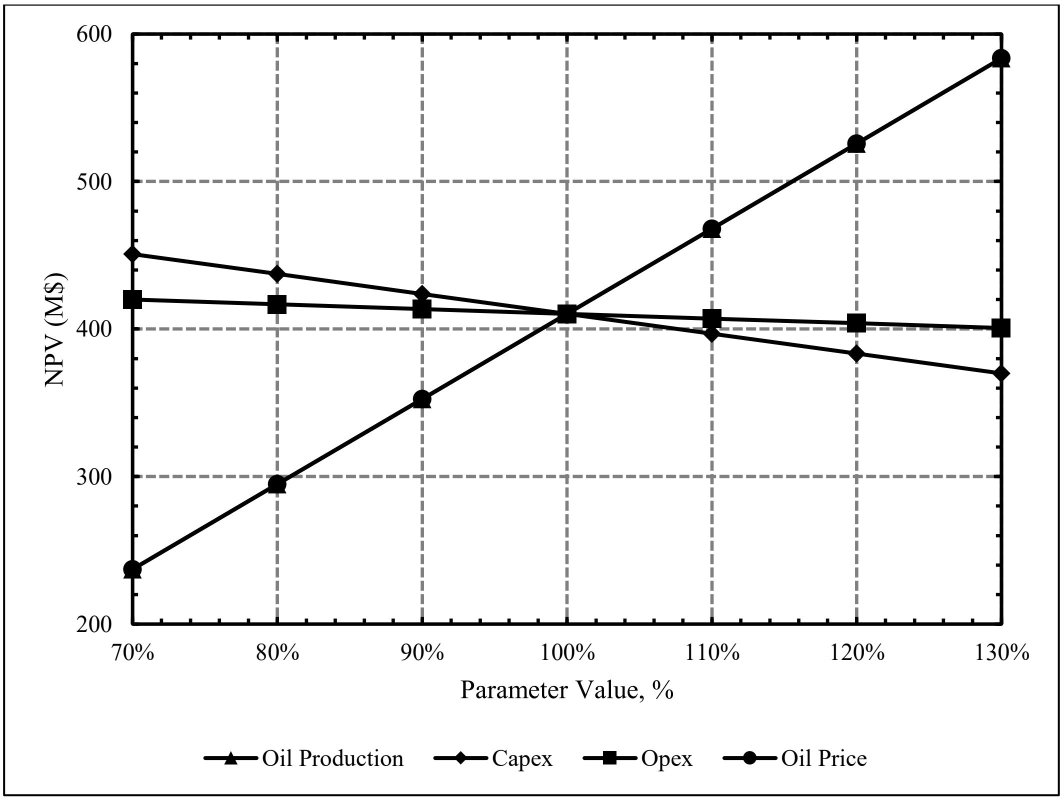

Figure 12. Spider diagram LSWI 1 using PSC.

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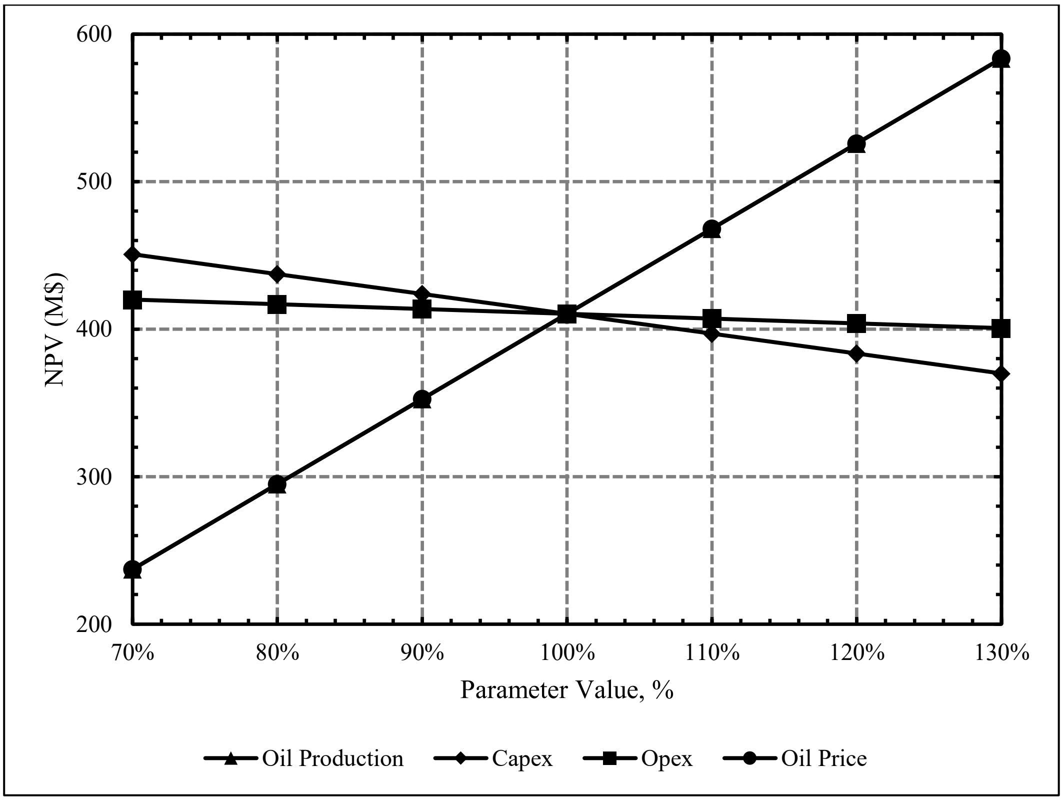

Figure 13. Spider diagram LSWI 1 using Gross Split.

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Table 1. Summary of LSWI field implementation (Dang, Nghiem, Nguyen, & Chen, 2015).

Author	Reservoir	Injected Brine/ Formation Water (ppm)	Formation Damage	Incremental Oil Recovery (%)
Webb (2004)	Sandstone	3,000/220,000	No	20
McGuire (2005)	Sandstone <Alaska North Slope>	150-1,500/15,000	No	13
Robertson (2007)	Sandstone <West Semlek Reservoir> <North Semlek Reservoir> <Moran Reservoir>	10,000/60,000 3,304/42,000 7,948/128,000	No	Recovery tends to decrease as the salinity ratio increases
Lager (2008)	Sandstone <Alaskan Oil Field>	2,600/16,640	No	10
Veledder (2010)	Sandstone <Omar Oil Field> <Isa Oil Field>	2,200/90,000	No	10-15
Secombe (2010)	Sandstone <Endicot Oil Field>	12,000/--	No	13
Skrettingland (2010)	Sandstone <Snorre Oil Field>	500/50,000	No	No significant change

Table 2. Pre-screening conditions for LSWI implementations (Reproduced from Dang, Nghiem, Nguyen, & Chen (2015)).

Property	Preferred Condition
Reservoir	• Sandstones • Carbonates (possibility)
Crude oil	• Must contain polar components (not effective with synthetic oil) • Viscosity is not too high for waterflooding
Clay minerals	• Reservoir must contain enough clay components • Medium sand with high CEC clay, porosity, permeability is preferred
Reservoir minerals	• Calcite • Dolomite
Formation water	Presence of divalent ions such as Ca^{2+} and Mg^{2+}
Initial wettability	• Oil wet or mixed wet reservoir • Small or ineffective in strong water wet reservoir
Reservoir temperature	Not limited
Reservoir depth	Not limited
Reservoir energy	Enough high pressure for achieving miscibility condition
Injected fluid	• Lower salinity concentration than formation water • Must contain divalent ions • Injected compositions must promote the adsorption of divalent ions • Sufficient CO_2 or chemical sources for hybrid LSWI implementation

Table 3. Summary of LSWI coreflood experiments.

Injected Brine		S_{or}		S_{or} Ratio	K_{rw}		K_{rw} Ratio	K_{ro}		Oil Recovery (%)	
WF	LSWI	WF	LSWI		WF	LSWI		WF	LSWI	WF	LSWI
174,156 ppm	NaCl 5,000 ppm	0.38	0.3	0.789	0.177	0.162	0.915	0.261	0.312	34.8	48.4
174,156 ppm	NaCl 5,000 ppm	0.6	0.43	0.717	0.215	0.207	0.963	0.347	0.3	21.9	43.8
NaCl 24,190 ppm, $CaCl_2$ 6,180 ppm, $Na_2S_2O_4$ 140 ppm	NaCl 790 ppm, $CaCl_2$ 210 ppm, $Na_2S_2O_4$ 140 ppm	0.367	0.318	0.866	0.052	0.043	0.827	0.34	0.29	50.2	57.5
NaCl 24,190 ppm, $CaCl_2$ 6,180 ppm, $Na_2S_2O_4$ 140 ppm	NaCl 1,000 ppm, $Na_2S_2O_4$ 140 ppm	0.367	0.376	1.025	0.052	0.051	0.981	0.34	0.29	50.2	50
NaCl 24,190 ppm, $CaCl_2$ 6,180 ppm, $Na_2S_2O_4$ 140 ppm	$CaCl_2$ 1,000 ppm, $Na_2S_2O_4$ 140 ppm	0.367	0.381	1.038	0.052	0.059	1.135	0.34	0.35	50.2	48.7

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NaCl 124,717 ppm, $MgCl_2$ 28,704 ppm, $MgSO_4$ 85.5 ppm, $CaCl_2$ 99,231 ppm	NaCl 20.1 ppm, $MgCl_2$ 28.1 ppm, $MgSO_4$ 137.8 ppm, $CaCl_2$ 276.9 ppm, $NaHCO_3$ 385.5 ppm	0.58	0.56	0.966	0.043	0.021	0.488	0.99	0.99	36.8	39.1
NaCl 124,717 ppm, $MgCl_2$ 28,704 ppm, $MgSO_4$ 85.5 ppm, $CaCl_2$ 99,231 ppm	NaCl 20.1 ppm, $MgCl_2$ 28.1 ppm, $MgSO_4$ 137.8 ppm, $CaCl_2$ 276.9 ppm, $NaHCO_3$ 385.5 ppm	0.395	0.27	0.684	0.054	0.051	0.944	0.95	0.95	53.4	68.2

Table 4. Base split percentage (*Permen ESDM No 08 Tahun 2017 Tentang Kontrak Bagi Hasil Gross Split*, 2017).

Hydrocarbon	Contractor	Government
Oil	43%	57%
Gas	48%	52%

Table 5. Variable and progressive components (Reproduced from Roach & Dunstan (2018)).

Components	Entitlement split percentage charge	Remarks
Status of field	+5% (POD I), +3% (POD II)	In the event production in soon-to-be terminated working area continues without POD, there is a 0% revision to the entitlement split
Location of field	0% (Onshore), 8 to 16% (Offshore)	Offshore percentages depend on sea depth, as follows: • Below/equal to 20 meters: +8% • Above 20 meters, but below/equal to 50: +10% • Above 50 meters, but below/equal to 150: +12% • Above 150 meters, but below/equal to 1000: +14% • Above 1000 meters: +16%
Depth of reservoir	1%	If vertical depth of wells exceeds 2500 meters
Availability of supporting infrastructure	0% (Well developed), 2% (New Frontiers Offshore), 4% (New Frontiers Onshore)	Increased percentage only awarded where supporting infrastructure (such as roads) is not available
Reservoir type	0% (Conventional), 16% (Unconventional)	Increased percentage for coal-bed methane and shale reservoirs
CO_2 content	0 to 4%	Increased percentage dependent on percentage of CO2 content above 5%, as follows: • Below 5%: +0% • Above/equal to 5%, but below 10%: +0.5% • Above/equal to 10%, but below 20%: +1% • Above/equal to 20%, but below 40%: +1.5%

		• Above/equal to 40%, but below 60%: +2% • Above/equal to 60%: +4%
H_2S content	0 to 5%	Increased percentage dependent on H2S content above 100 ppm, as follows: • Below 100ppm: +0% • Above/equal to 100ppm, but below 1000: +1% • Above/equal to 1000ppm, but below 2000: +2% • Above/equal to 2000ppm, but below 3000: +3% • Above/equal to 3000ppm, but below 4000: +4% • Above/equal to 4000ppm: +5%
Oil specific gravity	1%	Increased percentage if specific gravity above 25 API
Local content	0 to 4%	Increased percentage dependent on level of local content usage based on existing regulations, as follows: • Below 30%: +0% • Above/equal to 30%, but below 50: +2% • Above/equal to 50%, but below 70: +3% • Above/equal to 70%, but below 100: +4%
Stage of production	0 to 10%	Increased percentage dependent on whether primary, secondary or tertiary production, the latter including enhanced oil recovery, as follows: • Primary: +0% • Secondary: +6% • Tertiary: +10%
Progressive component		
Oil price	Formulaic-based approach	(85 – ICP) x 0.25. ICP is the Indonesian Crude Oil Price determined by the ESDM in accordance with applicable laws and regulations
Gas price	Formulaic-based approach	• Price below 7 US$/MMBTU: (7 - Gas Price) x 2.5 • Price above/equal to 7 to 10 US$/MMBTU: 0% • Price above 10 US$/MMBTU: (10 - Gas Price) x 2.5
Cumulative production	0 to 10%	• Below 30: +10% • Above/equal to 30, but below 60: +9% • Above/equal to 60, but below 90: +8% • Above/equal to 90, but below 125: +6% • Above/equal to 125, but below 175: +4% • Above 175: +0%

Table 6. All generation PSC scheme split calculation (Reproduced from PriceWaterCooper (2018)).

	New Contracts (%)	1995 Eastern Provinces PSC (%)	1995 PSC (%)	1985-1994 PSC (%)	Old PSC (%)
Tax Rate	40	44	44	48	56
Share of production after-tax:					
Government	Varies	65	85	85	85
Contractor	Varies	35	15	15	15
Contractor's production share before tax:	Ranges from 44.64-62.5				
35/ (100-44)		62.5			

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15/ (100-44)	26.79		
15/ (100-48)		28.85	
15/ (100-56)			34.09

Table 7. Tax Rate Calculations for PSC scheme (Reproduced from PriceWaterCooper (2018)).

PSC Era	Income Tax - General	Income Tax – Branch Profits	Combined Tax Rate	Production Share (Oil)	After Tax	Production Share (Gas)	After Tax
Pre-1984	45%	20%	56%	0.34	15%	0.68	30%
1984-1994	35%	20%	48%	0.29	15%	0.58	30%
1995-2007	30%	20%	44%	0.27	15%	0.54	30%
2008	30%	20%	44%	0.45	25%	0.71	40%
2009	28%	20%	42.4%	0.63	36%	0.71	41.14%
2010	25%	20%	40%	0.6	36%	0.69	41.14%
2013-2016	25%	20%	40%	0.58	35%	0.67	40%

Table 8. Input parameter for LSWI modelling.

Properties	Value/Notes
Low Salinity Modelling Method	Ion Exchange Relative Permeability Interpolation
Ion Exchange Component	Na-X
Range of Rel. Perm. Interpolation in Equivalent Fraction of Na-X	0.42-0.15
Number of Rel. Perm. Sets	2
Sorw Reduction for Set 2	0.717
Krw Reduction for Set 2	0.963
Change Kro curvature when Sor < 0.1	Yes
Calculate effective Sor	If Kro < 0.001
Corey Number when Sor < 0.1	2
Ion Exchange Reaction	$Na^+ + 0.5Ca\text{-}X_2 = 0.5Ca^{2+} + Na\text{-}X$
Cation Exchange Capacity for All Blocks	50 (mol/m3 x charge of ion)
pH of Initial Water	5.3552
Ca^{2+} Initial Concentration	680.001 ppm
Na^+ Initial Concentration	8427.99 ppm
Cl^- Initial Concentration	14555 ppm
Calcite Initial Volume Fraction	0.07

Table 9. Investment cost.

Case	CAPEX (thousand USD)	OPEX (thousand USD/year)
WF	132.50	4.00
LSWI 1	173.94	11.08
LSWI 2	172.73	10.80

Table 10. Economic analysis assumptions.

Parameter	Unit	Value
Oil Price	USD/bbl	60
Tax Rate	%	40
DMO	%	25
DMO Fee	%	100
Discount Rate	%	10

FTP (PSC)	%	20
After Tax Split (PSC)	%	35
Depreciation Rate	%	25
Depreciation Duration	years	5

Table 11. Gross Split parameter assumptions.

Base Case		
Variable	Status	Added Split
Status of Field	No POD	0%
Location	Onshore	0%
Depth	<2500 m	0%
Infrastructure	Well Developed	0%
Reservoir Type	Sandstone	0%
CO_2 Content	20%	1.5%
H_2S Content	5 ppm	0%
SG	30 °API	0%
Local Content	60%	3%
Production Stage	Primary	0%
Oil Price	60 USD/bbl	6.25%
Cumulative Production	<30 MMBOE	10%
WF		
Variable	Status	Added Split
Status of Field	POD II	3%
Location	Onshore	0%
Depth	<2500 m	0%
Infrastructure	Well Developed	0%
Reservoir Type	Sandstone	0%
CO_2 Content	20%	1.5%
H_2S Content	5 ppm	0%
SG	30 °API	0%
Local Content	60%	3%
Production Stage	Secondary	6%
Oil Price	60 USD/bbl	6.25%
Cumulative Production	<30 MMBOE	10%
LSWI		
Variable	Status	Added Split
Status of Field	POD II	3%
Location	Onshore	0%
Depth	<2500 m	0%
Infrastructure	Well Developed	0%
Reservoir Type	Sandstone	0%
CO_2 Content	20%	1.5%
H_2S Content	5 ppm	0%
SG	30 °API	0%
Local Content	60%	3%
Production Stage	EOR	10%
Oil Price	60 USD/bbl	6.25%
Cumulative Production	<30 MMBOE	10%
Total Contractor Split		
Base Case	WF	LSWI

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63.75%	72.75%	76.75%

Table 12. PSC calculation spreadsheet for base case.

	Year	0	1	2	3	4	5
Capital Cost	M$	-	-	-	-	-	-
Capital Cost Depreciation	M$	0	0	0	0	0	0
Non-Capital Cost	M$	0	0	0	0	0	0
Cost to be Recovered	M$	0	0	0	0	0	0
Production	Mbbl	0	28	0	0	0	0
Price	$/bbl	0	60	60	60	60	60
Gross Revenue	M$	0	1,702	3	1	1	0
Contr Split After Tax	%	35	35	35	35	35	35
Effective Tax Rate	%	40	40	40	40	40	40
Contractor Split (before tax)	%	58	58	58	58	58	58
Govt Split (before tax)	%	42	42	42	42	42	42
FTP	%	20	20	20	20	20	20
FTP	M$	0	340	1	0	0	0
Gross Revenue after FTP	M$	0	1,362	3	1	1	0
Investment Credit	M$	0	0	0	0	0	0
Cost Recovery (Recoverable Cost)	M$	0	0	0	0	0	0
Unrecovered Cost	M$	0	0	0	0	0	0
ETS	M$	0	1,362	3	1	1	0
CONTRACTOR SHARE	M$	0	993	2	0	0	0
Contr FTP	M$	0	199	0	0	0	0
Contr Equity	M$	0	794	2	0	0	0
DMO, 25%	M$	0	248	0	0	0	0
DMO delivered	M$	0	248	0	0	0	0
DMO fee (25%Price))	M$	0	248	0	0	0	0
Taxable Share	M$	0	993	2	0	0	0
Govt.Tax	M$	0	397	1	0	0	0
Net Contractor Share	M$	0	596	1	0	0	0
Total Contractor Take	M$	0	596	1	0	0	0
Contr.Cash Flow	M$	0	596	1	0	0	0
Govt FTP	M$	0	142	0	0	0	0
Govt Equity	M$	0	567	1	0	0	0
Total Indonesia Take	M$	0	1,106	2	0	0	0
Contractor NPV @ 10 %	M$	494					

Table 13. Gross Split calculation spreadsheet for Base Case.

	Year	**0**	**1**	**2**	**3**	**4**	**5**
Capital Cost	M$	-	-	-	-	-	-
Capital Cost Depreciation	M$	0	0	0	0	0	0
Non-Capital Cost	M$	0	0	0	0	0	0
Production	Mbbl	0	28	0	0	0	0

Price	$/bbl	60	60	60	60	60	60
Gross Revenue	M$	0	1,702	3	1	1	0
Contr Split Percentage	%	63.75	63.75	63.75	63.75	63.75	63.75
Effective Tax Rate	%	40	40	40	40	40	40
CONTRACTOR SHARE	M$	0	1,085	2	0	0	0
Contr Split	M$	0	1,085	2	0	0	0
DMO, 25%	M$	0	271	1	0	0	0
DMO fee (25%Price))	M$	0	271	1	0	0	0
Taxable Share	M$	0	1,085	2	0	0	0
Govt.Tax	M$	0	434	1	0	0	0
Net Contractor Share	M$	0	651	1	0	0	0
Contr.Cash Flow	M$	0	651	1	0	0	0
Govt Split	M$	0	617	1	0	0	0
Total Indonesia Take	M$	0	1,051	2	0	0	0
Contractor NPV @ 10 %	M$	539					

Table 14. NPV summary (thousand USD).

Case	PSC	Gross Split
Base Case	493.6	539.5
WF	399.5	513.0
LSWI 1	410.3	557.1
LSWI 2	405.5	553.1

Table 15. NPV percentage change compared to Base Case.

Case	PSC	Gross Split
Base Case	-	-
WF	-19.07%	-4.91%
LSWI 1	-16.83%	3.28%
LSWI 2	-17.85%	2.52%